Plains CO_2 Reduction (PCOR) Partnership Monthly Update
September 1–30, 2016

PHASE III ACTIVITIES

Task 1 – Regional Characterization (Wesley D. Peck)

Highlights

- Submitted Deliverable (D) 1 Entitled "Review of Source Attributes" on September 29, 2016.
- Presented "Important Site Selection Traits" as part of the "Carbon Capture and Sequestration (CCS) Technical Discussion Series: Site Selection" Webinar to the California Air Resources Board on September 26, 2016.
- Updated existing text and added new text material to Chapters 6 (CCS Deployment) and 7 (Path Forward) of the Regional Carbon Sequestration Atlas (D81).
- Continued work on regional oilfield models to investigate production-based estimations of CO_2 storage in abandoned oil fields. This effort included the following:
  - Completed distributing properties in the Beaver Creek field model.
  - Continued digitizing needed logs for the Gooseneck field model.
- Refined a new outline to summarize plans to update the Bell Creek portion of the partners-only Decision Support System Web site with newer approved information from the U.S. Department of Energy (DOE) and Denbury Onshore (Denbury).
- Continued activities to update the content of the **PCOR Partnership general database**, including the following:
  - Updated North Dakota and Montana Petra projects with the latest general well information from each state's online resources: 69 new North Dakota wells and six new Montana wells added.
  - Updated North Dakota production data.
  - Updated Manitoba project.
  - Completed scan for additional Wyoming well logs. Worked on data compilation and download.
  - Continued database preventive maintenance of Petra projects.
- With regard to the **Williston Basin** CO_2 Storage Sink Relative Permeability Laboratory Characterization:
  - Generated relative permeability curves.
  - Continued work on a paper to be submitted to the Greenhouse Gas Control Technologies (GHGT)-13 Conference.
- With regard to the **Aquistore** project's static modeling and dynamic predictive simulations effort:
  - Continued to download and process injection and pressure data as available.

- Continued work on a draft paper for the GHGT-13 conference entitled "Numerical Modeling of the Aquistore CO_2 Storage Project," which was sent to Petroleum Technology Research Centre (PTRC) for review.
- Continued work on a draft paper and PowerPoint presentation entitiled "A Numerical Simulation Update of the Aquistore CO_2 Storage Project" for the American Institute of Chemical Engineers conference.
- Ran a predictive simulation utilizing the existing model at PTRC's request.

Task 2 – Public Outreach and Education (Daniel J. Daly)

Highlights

- Received approval for D16 – Fort Nelson Test Site Fact Sheet (update) on September 6, 2016.
- Received approval for a value-added Phase II fact sheet update entitled "CO_2 Sequestration Test in a Deep, Unminable Lignite Seam," on September 6, 2016.
- Continued work on a GHGT-13 conference paper on PCOR Partnership outreach activities entitled "Outreach Lessons Learned."
- Continued work on a GHGT-13 conference paper being written in collaboration with PTRC.
- Contined work on a draft of the Bell Creek Fact Sheet (D15).
- Continued work on the value-added update of the Phase II Terrestrial Sequestration fact sheet.
- Continued efforts with regard to the public Web site (www.undeerc.org/pcor), including the following:
  - Continued work on updates to the public PCOR Partnership Web site.
  - Continued ongoing identification and repair of broken links.
- Continued collaborative efforts with Prairie Public Broadcasting (PPB), including the following:
  - Continued work on documentary D21 (The Bell Creek Story), including the following:
    - Traveled to Billings, Montana, September 8–9, 2016, with the PPB film crew to interview Tom Richmond.
    - Initiated postproduction editing of a Denbury-specific section of the documentary.
    - Conducted an interview with Nick Azzolina, The CETER Group (CETER), at the EERC on September 12, 2016.
    - Traveled to Fargo, North Dakota, to conduct an interview with Steve Melzer, Melzer Consulting, on September 13, 2016.
    - Held a conference call September 26, 2016, with representatives from PPB to discuss the content of the script, overall progress, and the schedule.
    - Continued script development and interview transcript preparation.
    - Worked with PPB on a video cover.
  - Continued work on Documentary D22 (Coal and the Modern Age), including the following:
    - Prepared the Sean Adams' interview transcript for insertion into the script.
    - Continued a review of the PPB budget regarding the potential for additional travel for Documentary D22.

Task 3 – Permitting and NEPA (National Environmental Policy Act) Compliance (Charles D. Gorecki)

Highlights

- Submitted D8 entitled "Permitting Review – Update 3" on September 29, 2016.
- Continued the final review and edit of the regulatory permitting document for the PCOR Partnership region (D76 – Regional Regulatory Perspective). Discussed the review with a consultant from CETER, including comments made by the PCOR Partnership Technical Advisory Board (TAB) during the meeting held in conjunction with the PCOR Partnership Annual Membership Meeting and Workshop.
- Notified a representative at the North Dakota Industrial Commission (NDIC) that the electrical panels have been removed from the Lignite site in Burke County, North Dakota.

Task 4 – Site Characterization and Modeling (Charles D. Gorecki)

Highlights

- **Bell Creek** test site activities included the following:
  - Updated PCOR Partnership Site Characterization Best Practices Manual (BPM) (D35) outline based on internal review meeting. Incorporated suggestions into outline regarding similarities/differences between enhanced oil recovery (EOR) and saline storage practices. Second meeting is scheduled to continue BPM outline evaluation.
  - Continued work on **modeling**, including the following:
    - Worked on integrating relevant data into one Petrel project for petrophysical evaluation, including all pulsed-neutron log (PNL) wells and core data. This will be used to assess petrophysical properties for input into the Version 3 model.
    - Evaluating Bell Creek petrophysical properties for input into Version 3 model, including shale volume and porosity logs.

Task 5 – Well Drilling and Completion (John A. Hamling)

This task ended in Quarter 3 – Budget Period (BP) 4, Year 7 (June 2014).

Task 6 – Infrastructure Development (Melanie D. Jensen)

Highlights

- Assisted the Energy & Environmental Research Center's (EERC's) Emissions and Carbon Capture Group Lead on a PowerPoint presentation on CO_2 capture efforts at the EERC for the PCOR Partnership Annual Membership Meeting and Workshop.

Task 7 – CO_2 Procurement (John A. Harju)

This task ended in Quarter 4 – BP4, Year 6 (September 2013).

Task 8 – Transportation and Injection Operations (Melanie D. Jensen)

This task ended in Quarter 4 – BP4, Year 8 (September 2015).

Task 9 – Operational Monitoring and Modeling (John A. Hamling and Larry J. Pekot)

Highlights

- Submitted a memo on September 20, 2016, verifying the most current injection numbers for Bell Creek, as requested by DOE National Energy Technology Laboratory (NETL).
- Sent an image and caption illustrating a Bell Creek 4-D seismic amplitude test to William Aljoe (DOE) for inclusion in the DOE monitoring, verification, and accounting (MVA) BPM after receiving approval from Denbury.
- Sent GHGT-13 conference papers on Bell Creek MVA, seismic, and minimum miscibility pressure (MMP) activities to Denbury for review. The titles and lead authors are as follows:
  - "Monitoring 3.2 million tons of CO_2 at the Bell Creek Oil Field" (John Hamling)
  - "4-D Seismic Monitoring of Injected CO_2 Enhances Geological Interpretation, Reservoir Simulation, and Production Operations" (Shaughn Burnison)
  - "Impact of CO_2 Impurity on MMP and Oil Recovery Performance of Bell Creek Oil Field" (Lu Jin)
- Continued work on the life cycle analysis (LCA) of oil produced during EOR compared with oil produced conventionally, including the following:
  - Integrated the various parts of the Bell Creek-specific LCA model.
  - Performed quality assurance/quality control on the Bell Creek-specific LCA upstream, gate-to-gate, and downstream models for accuracy to ensure accurate, representative results.
  - Obtained data on the monthly volumes of CO_2 provided by the Lost Cabin and Shute Creek gas-processing plants and compared to the GREET model module prepared at the EERC using older, publicly available information. Agreement was quite good. Based on these data, the Bell Creek-specific LCA model work is being completed.
  - Incorporated information from Denbury into the spreadsheet and GREET models. The unavailability of these data previously resulted in submission of a preliminary milestone report (Milestone [M] 57) until it could be updated using actual data from Bell Creek provided by Denbury. Preparation of the draft update of M57 is occurring simultaneously with preparation of the LCA final report (D105).
- **Bell Creek** injection-phase site activities included the following:
  - Continued reservoir pressure and distributed temperature monitoring of the 05-06 OW (observation well) from the permanent downhole monitoring system using the casing-conveyed pressure–temperature gauges and fiber-optic distributed temperature system:
    - Near-continuous operation since April 2012.
  - Continued dynamic reservoir pressure and multiphase fluid flow simulation efforts:
    - Consistent progress since April 2011.
    - History match is complete for Bell Creek Phases 1–3. Prediction simulation is complete for Bell Creek Phases 1 and 2. CO_2 migration simulation is complete for Bell Creek Phases 3–7.
    - Continued processing prediction/injection historical data for wells in Bell Creek Phase 4 and the nearby area and developing a simulation model to be used for history match and prediction simulation of the Bell Creek Phase 4 area.
  - Continued working with the fall 2015 4-D surface seismic data set from Bell Creek, including the following:

- ♦ Created 4-D difference maps from each of the single vintage data sets, and started prestack analysis to investigate isolating the pressure component from the CO_2 response on the difference displays.

- Resumed Bell Creek microseismic data processing. Testing parameters to improve signal-to-noise ratio and to detect seismic events.
- Developed prioritized list of target wells for logging as part of the fall 2016 enhanced PNL program. Plans for the PNL program will be discussed with Denbury as part of the agenda for an October 17, 2016, update meeting in Plano, Texas.
- Used the most recent publicly available data to determine that cumulative total CO_2 gas injection is 5,585,322 metric tons through July 31, 2016. This value represents the total gas volume injected, which includes purchase and recycle streams and is NOT corrected for a gas composition of approximately 98% CO_2 (Table 1).
- As of July 31, 2016, the most recent month of record, 3.247 million tonnes of total gas (composition of approximately 98% CO_2) has been purchased for injection into the Bell Creek Field, equating to an estimated 3.192 million tonnes of CO_2 stored (Table 2), with the difference comprising other trace gases in the purchase gas stream. A separate methodology from that used to calculate total gas injected was used to calculate a cumulative associated CO_2 storage volume estimate by correcting the gas purchase volume (approximately 98% CO_2) obtained from Denbury's custody transfer meter with gas compositional data.
- A summary of all oil and CO_2 gas stream samples collected for analyses to date is provided in Table 3.
- Collected the third round of Bell Creek oil samples for oil compositional monitoring September 19–22, 2016, with a representative from Denbury from the following wells: 21-14, 04-04, 28-02, 56-14R, 21-10, and 32-02.
- Tested WINPROP modeling options as a way to validate experimental data from the vanishing interfacial tension (VIT) technique. This technique is used to determine MMP for oil with various gases. Continued investigating the feasibility of using equation of state to mimic the VIT–MMP experimental process.

Table 1. Bell Creek CO_2 Gas Injection Totals for July 2016 (cumulative totals May 2013 to July 2016)[1]

	July 2016 Injection
Total, Mscf	2,924,974
Total, U.S. tons[2]	167,304
Total, metric tons[2]	151,923
Cumulative Total, Mscf [2]	107,534,209
Cumulative Total, U.S. tons[2,3]	6,150,787
Cumulative Total, metric tons[2,3]	5,585,322

Source: Montana Board of Oil and Gas (MBOG) database.

[1] There has been a lag in posting of injection/production volumes to the MBOG database. Total gas injection volumes are ***NOT CORRECTED*** for gas composition and include the combined purchased and recycled gas streams.

[2] This was calculated using a conversion of 17.483 Mscf/U.S. ton and 19.253 Mscf/metric ton.

[3] Cumulative totals are for the period from May 2013 to the month listed.

Table 2. Cumulative Total Gas Purchased and Estimated Associated CO_2 Storage Volumes for the Bell Creek Field[1]

	July 2016 Gas Volume
Monthly Total Gas Purchased, MMscf[2]	509
Monthly Total Gas Purchased, million tons[2]	0.029
Monthly Total Gas Purchased, million tonnes[2]	0.026
Cumulative Total Gas Purchased, MMscf[2,3]	62,513
Cumulative Total Gas Purchased, million tons[2,3]	3.576
Cumulative Total Gas Purchased, million tonnes[2,3]	3.247
Cumulative Total CO_2 Stored, MMscf[3,4]	61,454
Cumulative Total CO_2 Stored, million tons[3,4]	3.515
Cumulative Total CO_2 Stored, million tonnes[3,4]	3.192

[1] Conversion factors of 17.483 Mscf/ton and 19.253 Mscf/tonne were used to calculate volumes.
[2] Total gas-purchased volumes are ***NOT CORRECTED*** for gas composition.
[3] Cumulative totals are for the period from May 2013 to the month listed.
[4] Total gas CO_2 stored volumes are ***CORRECTED*** for gas composition.

Table 3. Oil and CO_2 Gas Stream Sampling and Analyses

Stream(s)	Dates Sampled
Production: Oil[1]	Jan. 2014, March 2014,[2] May 2014, June 2014, July 2014, Sept. 2014, Oct. 2014,[2] Jan. 2015,[2,3] May 2015,[3,4] June 2015,[3] Nov. 2015,[3,5] May 2016,[3,6] Sept. 2016[3,7]
Production: CO_2 Gas[1]	Sept. 2014,[2] Nov./Dec. 2014, Jan. 2015,[8] March 2015, July 2015
Purchase/Recycle: CO_2 Gas[9]	May 2014,[10] June 2014, July 2014, Sept. 2014, Oct. 2014, April 2015, July 2015, Sept. 2015, Jan. 2016, July 2016

[1] Wells 56-14R, 32-02, and 05-06 unless otherwise noted.
[2] Wells 56-14R and 32-02 only.
[3] Samples collected but not analyzed.
[4] Wells 32-02 and 05-06 only.
[5] Wells 56-14R and 05-06 only.
[6] Wells 56-14R, 05-06, 04-04, 28-02, 21-10, and 21-14.
[7] Wells 56-14R, 32-02, 04-04, 28-02, 21-10, and 21-14.
[8] Well 05-06 only.
[9] Both purchase and recycle streams unless otherwise noted.
[10] Purchase stream only.

Task 10 – Site Closure (John A. Hamling)

Highlights

- Nothing to note at this time.

Task 11 – Postinjection Monitoring and Modeling (John A. Hamling and Larry J. Pekot)

Highlights

- Submitted D55 entitled "Bell Creek Test Site – Development of Cost-Effective Long-Term Monitoring Strategy" on September 30, 2016. The report was sent to Denbury for concurrent review.

Task 12 – Project Assessment (Loreal V. Heebink)

Highlights

- Worked on compiling the annual report.

Task 13 – Project Management (Charles D. Gorecki)

Highlights

- Hosted the PCOR Partnership Annual Membership Meeting and Workshop September 13–15, 2016, in Grand Forks, North Dakota, at the EERC.
  - Hosted a Premeeting Workshop on September 13, 2016, with presentations on CO_2 capture technology and geologic characterization for CO_2 storage. Provided tours to highlight the EERC's CO_2 capture pilot facility, mineralogy/core characterization, geomechanical characterization, and gas/fluid characterization capabilities.
  - Hosted one and a half days of presentations pertaining to current PCOR Partnership activities and subsequent projects attributed to the activities and lessons learned from the PCOR Partnership. Presented the 2016 PCOR Partnership Pioneer Award to Wayne Rowe, Schlumberger Carbon Services.
  - The final attendance was 125 attendees (64 partners, presenters, or guests and 61 EERC employees) from 49 organizations (Figure 1).
- Hosted a PCOR Partnership TAB meeting on September 13, 2016, prior to the PCOR Partnership Premeeting Workshop. TAB members who were attending the PCOR Partnership Annual Membership Meeting participated. Seven of the nine members of TAB attended. Topics discussed included PCOR Partnership BPMs, regulatory permitting deliverables, and the upcoming peer review.
- Presented a PCOR Partnership overview entitled "The Plains CO_2 Reduction Partnership: Carbon Management Through the Development of Technologies for CCS Deployment" at the second U.S.–China Clean Coal Industry Forum (CCIF) in Ordos, Inner Mongolia, China, held September 9–10, 2016.
- Presented, by request, at the North Dakota Building Trades Convention in Bismarck, North Dakota, on September 29, 2016.

Figure 1. Participants at the 2016 PCOR Partnership Annual Membership Meeting and Workshop.

- Received feedback from PCOR Partnership TAB member Lynn Helms on the Adaptive Management Approach BPM (D102). Once all comments from TAB have been received, a revised version of the document will be issued.
- Held a task leader meeting September 6, 2016. Topics discussed included Bell Creek and Aquistore project updates, PCOR Partnership Annual Membership Meeting and Workshop planning, and task leader updates.
- Completed deliverables and milestones in September:
  - August monthly update
  - Task 1: D1 – Review of Source Attributes
  - Task 3: D8 – Permitting Review – Update 3
  - Task 11: D55 – Bell Creek Test Site – Development of Cost-Effective Long-Term Monitoring Strategy

Task 14 – RCSP Water Working Group (WWG) Coordination (Ryan J. Klapperich)

Highlights

- With regard to the *International Journal of Greenhouse Gas Control* (IJGGC) Special Issue:
  - Continued final revisions to the introduction article with a consultant from CETER.
  - Compiled an initial list of existing publications to include in the Special Issue and discussed with a consultant from CETER.
- Followed up with a DOE NETL representative from the Innovative Energy & Water Process Team regarding potential data sources for data on CCS produced water quality in North Dakota. Worked on reviewing a draft manuscript on treating CCS-extracted brines for the representative.
- Distributed the WWG Annual Meeting (held August 18, 2016) notes and presentation files on September 1, 2016.
- Held the quarterly conference call on September 28, 2016. Topics included the following:
  - Reviewed the annual meeting and discussed feedback, which was mostly positive.
  - Provided the group with an update on the status of the virtual IJGGC Special Issue, which is still in progress. Discussed a time line for completion of the issue.
  - Requested WWG members review the WWG Web site.
  - Discussed the final WWG deliverable (D107, due February 2018) and a time line for drafting an outline.

Task 15 – Further Characterization of the Zama Acid Gas EOR, CO_2 Storage, and Monitoring Project (Charles D. Gorecki)

This task ended in Quarter 2 – BP4, Year 7 (February 2014).

Task 16 – Characterization of the Basal Cambrian System (Wesley D. Peck)

This task ended in Quarter 2 – BP4, Year 7 (March 2014).

Travel/Meetings

- August 27 – September 2, 2016: traveled to Cape Town, South Africa, to attend and present at the 35th International Geological Congress.
- September 6–13, 2016: traveled to Ordos, China, to present at the second U.S.–China CCIF.
- September 8–10, 2016: traveled to Billings, Montana, to conduct an interview with Tom Richmond for the upcoming Bell Creek documentary (D21).
- September 12 and 19, 2016: traveled to Kenmare, North Dakota, to remove electrical panels still on-site.
- September 12–16, 2016: off-site staff member traveled to the EERC offices in Grand Forks, North Dakota, to attend the PCOR Partnership Annual Membership Meeting and Workshop and to work on upcoming deliverables.
- September 13, 2016: traveled to Fargo, North Dakota, to conduct an interview with Steve Melzer for the upcoming Bell Creek documentary (D21).
- September 19–21, 2016: traveled to Minot, North Dakota, to attend the North Dakota Petroleum Council's Annual Meeting.
- September 19–23, 2016: traveled to Gillette, Wyoming, for oil sampling at the Bell Creek site.
- September 23, 2016: traveled to Fargo, North Dakota, for meetings with PPB to discuss the upcoming documentaries.
- September 29, 2016: traveled to Bismarck, North Dakota, to present at the North Dakota Building Trades Convention.

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